

REMARKS

Claims 1-3 and 5-9 are pending in this application. Claims 10-26 are withdrawn.

**Claims 1-3 and 5 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Visco, in view of U.S. Patent No. 4,537,843 to Shishikura et al. (hereinafter Shishikura) or U.S. Patent No. 6,312,853 to Zhang et al. (hereinafter Zhang).** Applicants traverse.

The Office Action asserts that Visco teaches a non-aqueous electrolyte secondary battery comprising a positive electrode, a negative electrode, and a non-aqueous electrolyte, where the positive electrode includes elemental sulfur, and the negative electrode includes silicon that stores lithium. The Office Action acknowledges that Visco does not teach that the electrolyte including a quaternary ammonium salt.

The Office Action relies on Shishikura and Zhang in an attempt to cure the deficiencies of Visco.

The Office Action states that Shishikura teaches the use of a quaternary ammonium salt as the electrolyte of an electrolytic solution.

Turning to Shishikura, the cited reference provides several examples of the materials used for the positive electrode (col. 7, line 61-col. 8, line 9). However, Shishikura fails to disclose the use of elemental sulfur as the material for the positive electrode.

Zhang describes that a solid composite cathode includes an electroactive sulfur-containing cathode material and a cationic polymer having quaternary ammonium salt groups (col. 4, lines 33 to 59). Zhang also describes examples of electrolytes (col. 16, line 6-col. 17, line 19). Furthermore, Zhang describes suitable materials for anode active materials (col. 15, line 58-col. 16, line 5). However, Zhang also fails to disclose the use of elemental sulfur as the material for the positive electrode.

None of the cited references, individually or combined, disclose or suggest, "...said **positive electrode includes elemental sulfur**, and said negative electrode includes silicon that stores lithium; and **said non-aqueous electrolyte includes a quaternary ammonium salt**," as recited in claim 1.

According to the claimed subject matter per claim 1, the non-aqueous electrolyte secondary battery has a positive electrode including elemental sulfur, a negative electrode including silicon that stores lithium, and a non-aqueous electrolyte including a quaternary ammonium salt. Thereby, as taught in the instant specification, the non-aqueous electrolyte secondary battery has increased energy density (*see, e.g.*, Table 3 and Inventive Examples 1, 3, 5, 7, 9, 11, 13, 15, 17 and 19, and the corresponding description in the specification). However, none of the cited references disclose or suggest this, and apparently are unaware of the unexpected improvement in charge-discharge efficiency.

Specifically in the battery of Shishikura, an electrically conductive polymer is used for the positive electrode and the negative electrode. This battery is operated by a reaction mechanism in which the positive electrode is doped with quaternary ammonium ions while the negative electrode is doped with anions by charging, and then the ions doped into the respective electrodes are undoped by discharging.

On the other hand, in the battery of Visco, during discharging, sulfur reacts with Li ions contained in the electrolyte to produce a lithium sulfide compound, and the Li ions are eluted from the negative electrode. During charging, the lithium sulfide compound is oxidized to produce sulfur and lithium ions, and then the lithium ions are absorbed into the negative electrode.

Therefore, the quaternary ammonium salt and anions serve as the charge carriers in the Shishikura, whereas Li ions serve as the charge carriers in Visco.

*Assuming arguendo*, if the electrolyte composed of the quaternary ammonium salt is used for the battery of Visco, it leads to the addition of a material that is not required for the reaction of Visco. It is well known by person skilled in the art that the addition of unnecessary material in a battery would cause an increase in weight and volume and deterioration in performance. The Examiner's position is not tenable. It would not have been obvious to substitute an electrolyte composed of the quaternary ammonium salt of Shishikura in Visco, as required by claim 1.

In the battery of Zhang, the quaternary ammonium salt is used as part of a cationic polymer, not as the electrolyte of the battery. Although Zhang describes an electrolyte, Zhang is *silent* to using the quaternary ammonium salt as the electrolyte. The quaternary ammonium salt of Zhang is incorporated, as part of the solid composite cathode, in the cationic polymer, i.e., a copolymer, and forms a huge cation. It is believed that this huge cation is not soluble in the electrolytic solution. Zhang states in col. 8, lines 23-26:

the cationic polymers of the present invention form complexes with the anion groups of polysulfides and retard the excessive out-diffusion of soluble polysulfides from the solid composite cathode.

The cationic polymer of Zhang is a material for forming the solid composite cathode. Thus, if the cationic polymer is soluble in the electrolytic solution, the cationic polymer does not function as described above.

Also in the battery of Visco, the product is lithium sulfide, which is a type of polysulfides. It is considered that since  $S^-$  or  $S_n^-$  is soluble in the electrolytic solution, the use of a cationic polymer can solve this problem.

In Zhang, however, the quaternary ammonium salt groups of the solid composite cathode are not used as the electrolytes, but as additives to the cathode. If the quaternary ammonium salt groups of the solid composite cathode are used as the electrolytes, it is believed that they are soluble in the electrolytic solution. As stated above, if the cationic polymer for capturing sulfide anions is dissolved and diffused in this solution, this prevents the suppression of the diffusion of the polysulfides into the solution.

Accordingly, the quaternary ammonium salt groups of the solid composite cathode of Zhang cannot be used as the electrolyte of the battery of Visco. The quaternary ammonium salt groups of the solid composite cathode of Zhang exists in the cathode, not in the electrolyte. If the quaternary ammonium salt groups of the solid composite cathode is present or soluble in the electrolyte, then the cationic polymer is dissolved and diffused in the solution, thereby *preventing* the function of suppressing the diffusion of polysulfides into the solution.

According to an embodiment of the present invention, the reversibility of charging/discharging of sulfur is enhanced when the quaternary ammonium salt is present in the electrolyte. Since the quaternary ammonium salt is soluble in the electrolyte or is sometimes the electrolyte itself, it does not include the mechanism of preventing the dissolution of polysulfides, which is incorporated in the solid composite cathode of Zhang. Accordingly, the solid composite cathode of Zhang is considerably different from the claimed non-aqueous electrolyte secondary battery in both structure and function. Accordingly, the rejection of claims 1-3 and 5 predicated on Visco, Shishikura, and Zhang should be withdrawn.

**Claims 1 and 6-9 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Visco in view of EP 1231651 (hereinafter Ikeda).**

Visco fails to disclose or suggest an electrolyte including a quaternary ammonium salt.

Ikeda is *silent* regarding an electrolyte including a quaternary ammonium salt. The combination of Visco and Ikeda does not suggest the claimed non-aqueous electrolyte secondary battery.

Claims 6-9 depend from claim 1 and include all of the features of that claim plus additional features, which are not taught or suggested by the cited references. Therefore, for at least these reasons, it is respectfully submitted that claims 6-9 also patentably distinguish over the cited references.

Withdrawal of the foregoing rejections is respectfully requested.

### **Conclusion**

In view of the above remarks, Applicants submit that this application should be allowed and the case passed to issue. If there are any questions regarding this Amendment or the application in general, a telephone call to the undersigned would be appreciated to expedite the prosecution of the application.

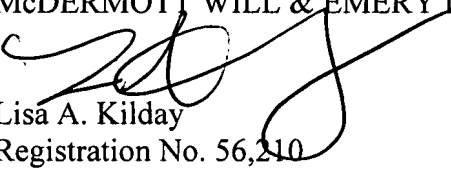
To the extent necessary, a petition for an extension of time under 37 C.F.R. 1.136 is hereby made. Please charge any shortage in fees due in connection with the filing of this paper,

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including extension of time fees, to Deposit Account 500417 and please credit any excess fees to such deposit account.

Respectfully submitted,

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